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Published:
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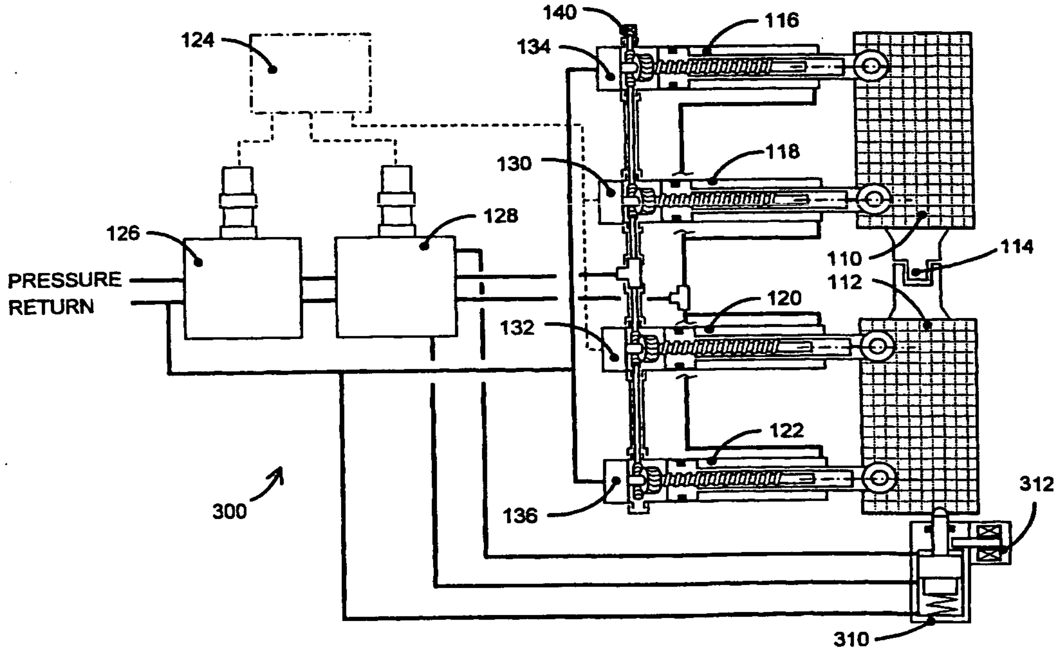
(54) **Title:** LOCKS AND LOCKING SYSTEMS



(57) **Abstract:** A thrust reverser (110, 112) is operated hydraulically but controlled by an independent electrohydraulic lock (310, 312). The electrohydraulic lock (310, 312) comprises a hook (Figure 4: 410) which is connected by a non-rigid link (Figure 4: 416, 418) to a piston (Figure 4: 422) which can be locked by a solenoid operated latch (Figure 5: 518).

WO 01/57382 A2

LOCKS AND LOCKING SYSTEMS

This invention relates to engine thrust reverser locks and locking systems.

Aerojet engines are commonly provided with a thrust reverser system comprising a gas baffle which is normally positioned so that it does not impede the rearward flow of jet gases, but which can be manoeuvred within the engine housing to cause at least a part of the jet gas flow to be directed forwards to generate a reverse thrust and produce an aircraft braking action. The gas baffle may comprise a number of doors in the engine housing which are normally kept closed, but which are openable to direct at least a part of the jet gas flow forwards, or a cowl within the engine housing which is moveable longitudinally of the engine to open a reverse thrust gas flow path. For reasons of safety, operation of a thrust reverser system is tightly controlled and locks are provided to hold the cowl or doors, in their closed position until the need for reverse thrust is confirmed.

One object of the invention is to provide a safe locking system for an engine thrust reverser.

According to a first aspect, the invention consists in a locking arrangement arranged to act directly on a thrust reverser gas baffle so as to prevent movement thereof, the locking arrangement being controlled independently of the gas baffle. The fact that the locking arrangement is independently operable means that, advantageously, the need for reverse thrust has to be confirmed by positively operating the locking arrangement.

In a preferred embodiment, the locking arrangement comprises at least one lock which acts directly on the gas baffle, and which is electrically controlled. The lock may be electromechanical e.g. solenoid-operated, or may be electrohydraulic e.g. hydraulically operated under the control of a solenoid controlled hydraulic valve. Alternatively, the lock may be hydraulically operated, and a solenoid operated pawl provided to selectively impede hydraulic operation.

According to a second aspect, the invention provides a lock for a thrust reverser gas baffle comprising a latch member which releasably engages to restrain motion of the baffle and an actuator connected to disengage it so as to release the baffle, wherein the connection between the actuator and the latch member is not rigid. The absence of complete rigidity in the connection between the actuator and the latch member means that the latch member can be disengaged without requiring the actuator to be operated. This facilitates, for example, servicing and inspection of the thrust reverser.

The non-rigid connection may comprise a length of cable or a hinged linkage. Alternatively, the connection could be effected by a two piece element, one piece of which can move relative to the other to permit the length of the element to reduce when the latch member is pulled back other than under control of the actuator. The element may be provided with resilient means acting between said pieces to urge the element towards its normal, non-reduced length.

In a preferred embodiment, the latch member comprises a pivotable hook which can be moved about its pivot to releasably engage and lock the thrust reverser baffle.

By way of example, the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a thrust reverser system;

Figure 2 is a schematic diagram of another thrust reverser system;

Figure 3 is a schematic diagram of a further thrust reverser system;

Figure 4 is a schematic diagram of a thrust reverser lock;

Figure 5 is an elevation of a thrust reverser lock shown in cross-section;

Figure 6 is a schematic diagram of another thrust reverser lock;

Figure 7 is a schematic diagram of a further thrust reverser lock; and

Figure 8 is a schematic diagram of yet another thrust reverser system.

The thrust reverser system 100 comprises a thrust reverser cowl divided into two sections 110 and 112 which can be deployed within a jet engine to deflect thrust in the forward direction. There is a structural connection 114 between cowl sections 110 and 112. The cowl is deployed and retracted by actuators 116, 118, 120 and 122 connected to the cowl sections 110 and 112. Each of the actuators 116 to 122 comprises a piston which is driven by pressure applied through a hydraulic system.

The pressures applied to the actuators 116 to 122 are controlled by an engine controller (FADEC) 124. FADEC 124 controls the hydraulic system driving the actuators 116 to 122 by selectively operating isolation control valve 126 and directional control valve 128. Two of the actuators 118 and 120 are each provided with a transducer 130 and 132 which provides signals indicative of the position of its respective actuator to the FADEC 124. The FADEC 124 can use these signals to adjust the hydraulic fluid feed to the actuators so that the cowl sections 110 and 112 are moved together.

Two of the actuators 116 and 122 are each provided with a ram lock 134 and 136. Each ram lock 134, 136 operates by locking the piston of its respective actuator against motion if the piston is not supplied with operating pressure. The piston rods of the actuators 116 and 122 are linked transversely by a synchronising shaft 138 which engages the piston rod of each actuator 116 to 122 via a respective worm gear arrangement. The synchronising shaft 138 ensures that the actuators are extended and retracted in synchronism with one another. The shaft 138 is provided with a feature 140 at one end which is adapted to engage a tool for manual deployment and retraction of the cowl.

An electromechanical lock 142 acts on cowl section 112. The lock 142 is operated independently from the actuators 116 to 122, which are under the control of the FADEC controller 124. Typically, the electromechanical lock 142 may be controlled by the pilot of the aircraft by means of a separate switch (not shown). As shown, lock 142 comprises a solenoid coil 144 through which passes an armature 146. The lock 142 may also comprise a sensing element such as switch 148 which is urged closed by the armature 146 when the lock 142 is in the open position. The lock 142 is activated when solenoid 144 is de-energised and armature 146 is caused, by a spring (not shown), to project in the manner of a pawl into a recess in cowl section 112 to restrain cowl motion. Cowl section 110 is also restrained by virtue of connection 114. When it is desired to deactivate lock 142, solenoid 144 is energised and armature 146 is attracted to it and retracts into the body of lock 142 to contact and close switch 148, which signals that the lock is disabled. The electromechanical lock 142 can, of course, be implemented in other forms.

The thrust reverser system 200 shown in Figure 2 is similar in many ways to that shown in Figure 1. The reference numerals of components described with reference to Figure 1 have been retained in Figure 2. The construction and function of these features will not be described in detail again since this information can be inferred from the description of Figure 1.

Thrust reverser system 200 comprises an electrohydraulic lock operating on cowl section 112. The electrohydraulic lock comprises a hydraulic lock 210, the pressurisation of which is under the control of a solenoid operated valve 212. The hydraulic lock 210 comprises a piston which can be displaced in a chamber within the lock upon application of suitable pressure. A piston rod extending from the piston can be moved, in the manner of a pawl, so as to engage and release cowl section 112. Lock 210 contains a spring which when the lock is depressurised, urges the piston outwards so that the rod extends into locking engagement with cowl section 112. The aforementioned situation pertains when solenoid operated valve 212 is closed. When the valve 212 is opened, the lock is pressurised and the piston moves against the action of the spring to retract the piston rod out of locking engagement with cowl section 112. Lock 210 may contain a sensing element such as a switch for determining when the piston rod is in the fully retracted position. It will be appreciated that the electrohydraulic lock could be implemented in other ways.

In Figure 3, as with Figure 2, components carried over from the thrust reverser system 100 will not be described in detail, and retain the same reference numerals as provided in Figure 1.

The thrust reverser system 300 comprises an electrohydraulic lock operating on cowl section 112. The electrohydraulic lock comprises a hydraulic lock 310 and a solenoid operated electromechanical lock 312. The hydraulic lock 310 is operated under control of directional control valve 128 which, in this embodiment, is controlled by FADEC 124. The hydraulic lock 310 comprises a piston which can be caused to move under appropriate pressurisation from the hydraulic system. A piston rod extending from the piston of lock 310 can thus be caused to move in the manner of a pawl and engage and lock cowl section 112 against undesired movement. Electromechanical lock 312 comprises an armature which moves under the action of a solenoid. The armature acts as a pawl and can engage the piston rod of hydraulic lock 310 such that the piston rod is maintained in locking engagement with cowl section 112. The electromechanical lock 312 is controlled via a separate control line independent of controller 124 and can be energised to permit the controller 124 to retract hydraulic lock 310 to release the cowl for movement. It will be apparent that there are further design alternatives for the electrohydraulic lock.

The lock 400 of Figure 4 comprises a hook 410 which can engage a feature 412 of a thrust reverser door to restrain motion thereof. To release the door for deployment, hook 410 can be pulled back about pivot 414 by actuator head 416 by way of a connection 418 which may be rigid. A spring 420 is connected to hook 410 and to a suitable anchor point. The spring 420 serves to urge hook 410 into its engaging position when actuator head 416 is not pulling against it.

Actuator head 416 comprises a rod 422 having a stop 424 at one end and being connected to a lock piston (not shown) at its other end. The lock piston may be driven hydraulically or electrically or a combination thereof. The piston can be moved to cause actuator head 416 to pull hook 410 (via connection 418) out of engagement with the door. Stop 424 lies within a chamber 426 within the actuator head 416 and the rod 422 extends from the stop 424 through an aperture in the actuator head 416. Chamber 426 contains a spring 428 positioned between stop 424 and an end wall of the chamber 426 nearest the hook 410, the spring being arranged to urge stop 424 against the end wall of chamber 426 remote from hook 410. When the lock piston is operated to pull rod 422 to the left, stop 424 acts on the end wall of chamber 426 remote from hook 410 to pull the actuator head 416 and hook 410 (via connection 418) out of engagement with the door. It will be appreciated that instead of rod 422 being attached to a lock piston, it could form part of an armature movable by a solenoid coil.

For maintenance purposes, it is desirable to be able to deploy the door without energising the system which causes rod 422 to pull hook 410 out of engagement with the door. However, it is usual for rod 422 to be immobile when the system is de-energised. In this situation, lock 410 can nevertheless be released to permit door deployment for inspection or servicing purposes. Hook 410 can be pulled out of engagement with the door and actuator head 416 moved to the left. In this operation, actuator head 416 moves to the left relative to immobile rod 422. This causes stop 424 to move to the right within and relative to chamber 426, compressing spring 428 as it does so. When it is desired to lock the cowl once more, actuator head 416 can be released allowing spring 426 to urge actuator 416 to the right relative to immobilised stop 424, and hook 410 can re-engage the door. The provision of a lost motion linkage within actuator 416 permits disengagement of hook 410 even where rod 422 is immobile and connection 418 is rigid.

The electrohydraulic lock 500 is a more detailed example of the generic type shown in Figure 4. The actuator 510 acting on hook 512 is of the kind described in Figure 3 comprising hydraulic lock 310 and electromechanical lock 312. The hydraulic components of actuator 510 comprise a piston 514 which can be caused to move to the left in Figure 5 on application of a suitable pressure differential such that the hook is pulled out of engagement with the door. The electromechanical components of actuator 510 comprise solenoid coil 516 and armature 518. When coil 516 is de-energised, the armature 518 is urged upwards by the coil spring 528 and engages a shoulder 530 on rod 520 when actuator 510 is depressurised in the position shown in Figure 5 with the hook 512 in the latched state. Before the rod 520 can be moved to the left to release the hook 512, the solenoid 516 has to be energised to withdraw the armature 518 downwards out of engagement with the shoulder 530 on the rod 520. In order to allow hook 512 to be manually retracted (e.g. for servicing purposes), the structure connecting rod 520 with hook 512 incorporates a two-part element comprising rod 522 which is capable of limited movement within sleeve 524. During manual retraction of hook 512, rod 522 collapses into sleeve 524 against the action of spring 526. This allows hook 512 to be manually retracted without moving rod 520, which would require energisation of actuator 510.

Lock 600 shown in Figure 6 is similar in many respects to lock 400 and features carried over from Figure 4 retain the same reference numerals and their function will not be described again in detail. Essentially, lock 600 differs from lock 400 in that the actuator head 610 is not compressible like actuator head 416, but rather the lost motion is provided by a hinged linkage 612 connecting actuator head 610 with hook 410.

Lock 700 shown in Figure 7 is similar in many respects to lock 600 and features carried over from Figure 6 retain the same reference numerals and their function will not be described again in detail. Lock 700, instead of a hinged linkage (612 in Figure 6), utilises a flexible cable 710 to connect actuator head 610 and hook 410 in order to provide for lost motion when hook 410 is retracted manually.

Thrust reverser system 800 shown in Figure 8 illustrates the implementation of hook-type locks for door sections. Thrust reverser system 800 is in many respects similar to thrust reverser system 100 shown in Figure 1. Thus, features carried over from Figure 1 retain the same reference numerals and will not be described in detail here. It will be appreciated that Figure 8 is merely a schematic representation and the thrust reverser system 800 could include the ram locks, sensors, synchronising shaft and structural interconnection between the door sections, all as shown in Figure 1.

To deploy door sections 110 and 112, the controller 124 provides appropriate pressurisation to hydraulic locks 810, 812, 814 and 816 which are connected in series, such that they sequentially release door sections 110 and 112. In order to provide for independent confirmation of the intention to deploy the thrust reverser, the door sections are provided with electrohydraulic locks 818 which are controlled independently of the controller 124, by the aircraft pilot.

The hooks of locks 818 are operated hydraulically, but their pressurisation is controlled by means of solenoid operated valve 820, which in turn is controlled by a pilot operated switch 822. It will be appreciated that solenoid operated valve 820 forms the electromechanical portion of electrohydraulic locks 818, which operate in the same way as the lock constituted by components 210 and 212 in Figure 2. It will also be understood that the number of electrohydraulic locks 818 can be varied. For example, two electrohydraulic locks could be provided on each door section, all four locks being controlled by valve 820.

CLAIMS

1. A locking arrangement arranged to act directly on a thrust reverser gas baffle so as to prevent movement thereof, the locking arrangement being controlled independently of the gas baffle.

2. A locking arrangement according to claim 1, comprising at least one latch member operable to releasably engage the baffle and restraining means operable to releasably restrain operation of the or each latch member.

3. A locking arrangement for a thrust reverser gas baffle, having at least one lock comprising a latch member which releasably engages to restrain the motion of the baffle and a lock actuator connected to disengage the latch member so as to release the baffle, wherein the connection between the latch member and the lock actuator is not rigid.

4. A locking arrangement according to claim 3, wherein the connection is resiliently deformable.

5. A locking arrangement according to claim 3 or 4, wherein the connection comprises an element having two pieces, one of which can move relative to the other to reduce the element's length when the latch member is retracted other than under the control of the lock actuator.

6. A locking arrangement according to claim 5, wherein one of the pieces is arranged to move within the other to permit said reduction.

7. A locking arrangement according to any one of claims 3 to 6, wherein the connection is hinged or flexible.

8. A locking arrangement according to any one of claims 3 to 7, wherein restraining means is provided for releasably restraining the motion of the or each latch member.

9. A locking arrangement according to claim 2 or 8, wherein the restraining means is operable independently of the baffle, and the or each latch member is operable, subject to the restraining means, with the baffle.

10. A locking arrangement according to any one of claims 2, 8 or 9 wherein the or each latch member is hydraulically operated and the restraining means is electromechanically operated.

11. A locking arrangement according to any one of claims 2 to 10 wherein the or each latch member is a hook which can be pivoted to releasably engage the baffle.

12. A thrust reverser system comprising a gas baffle, at least one baffle actuator for moving the baffle and a locking arrangement according to any one of the preceding claims for preventing movement of the baffle, wherein the arrangement is controlled independently of said at least one baffle actuator.

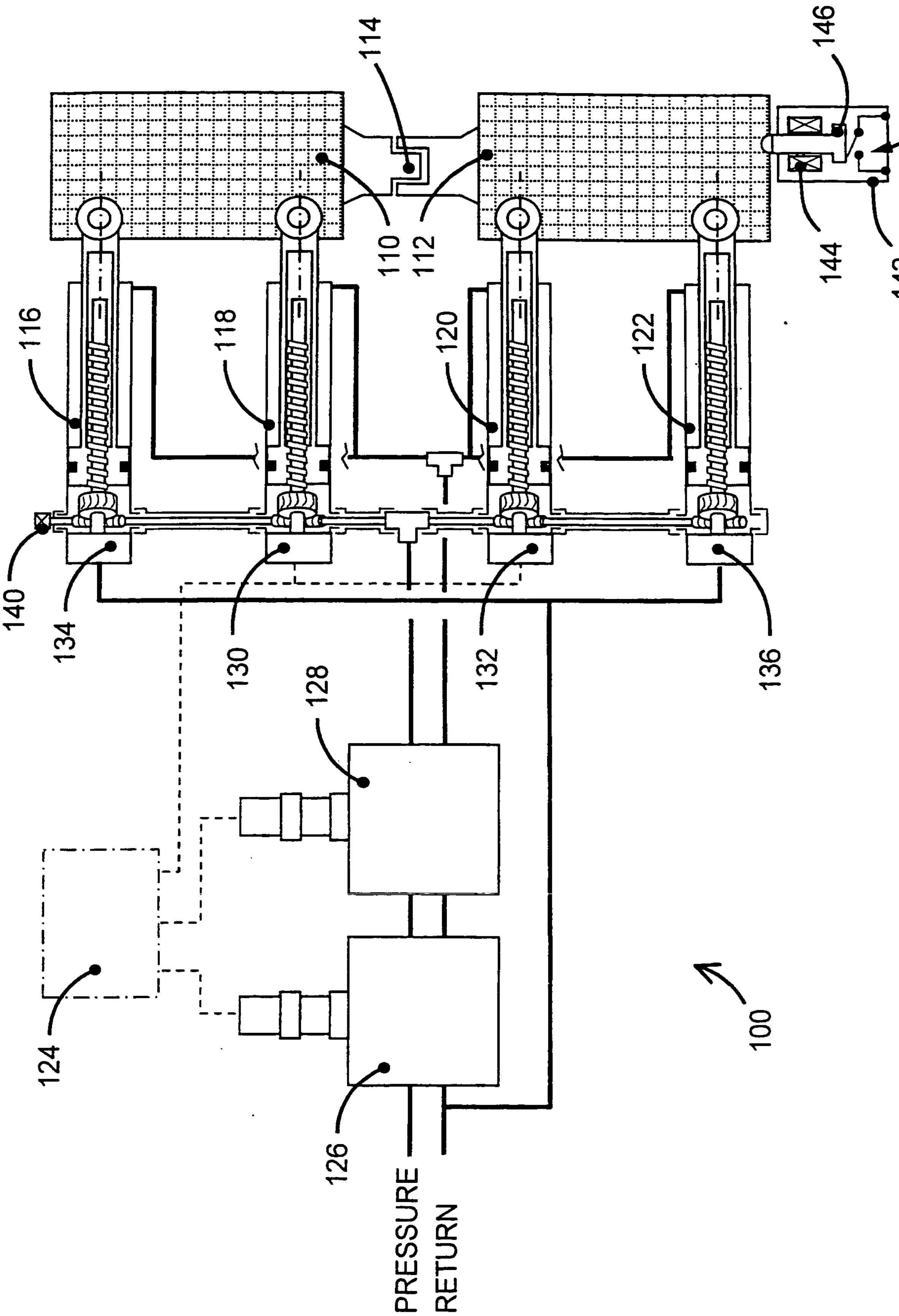

PRESSURE
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Figure 1

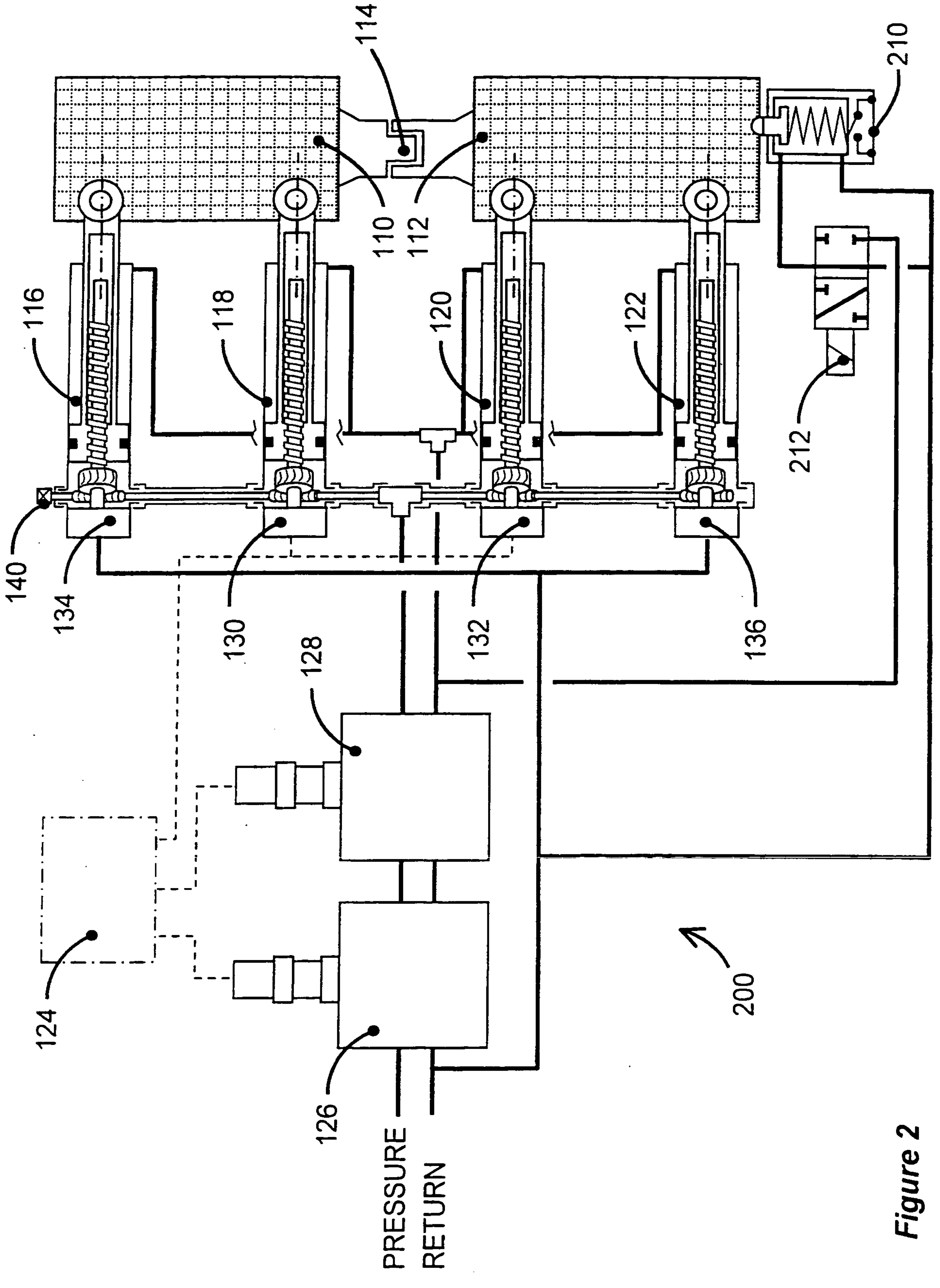
PRESSURE
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Figure 2

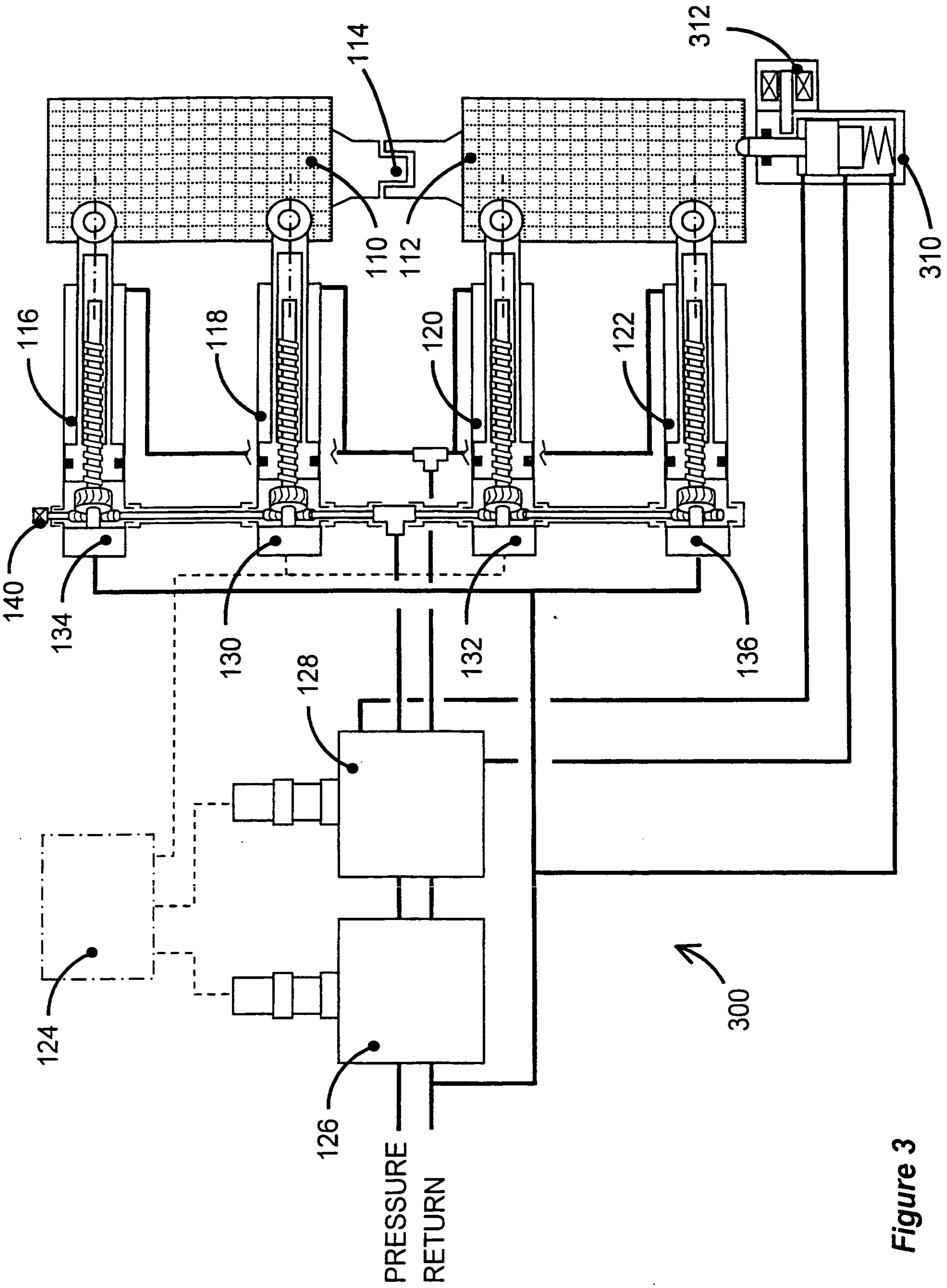
PRESSURE
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Figure 3

Figure 4

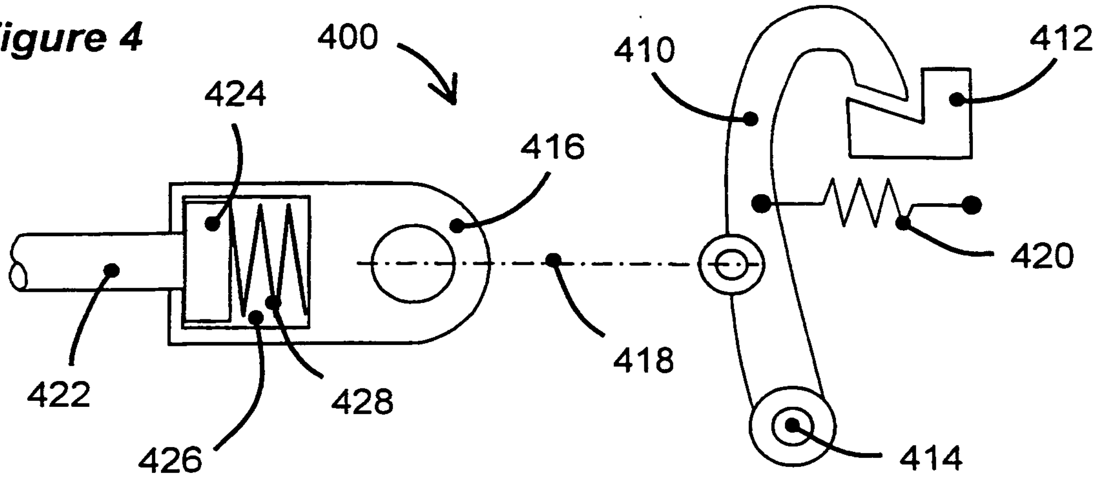


Figure 6

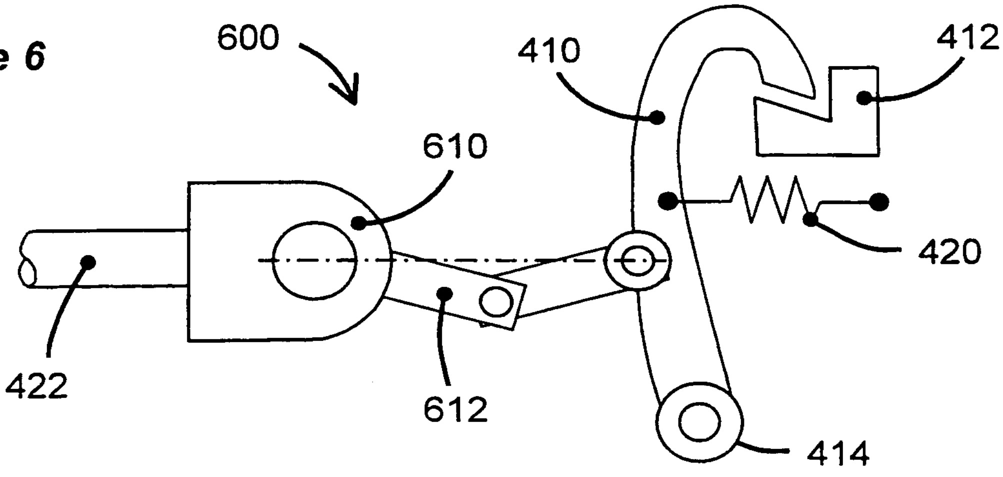
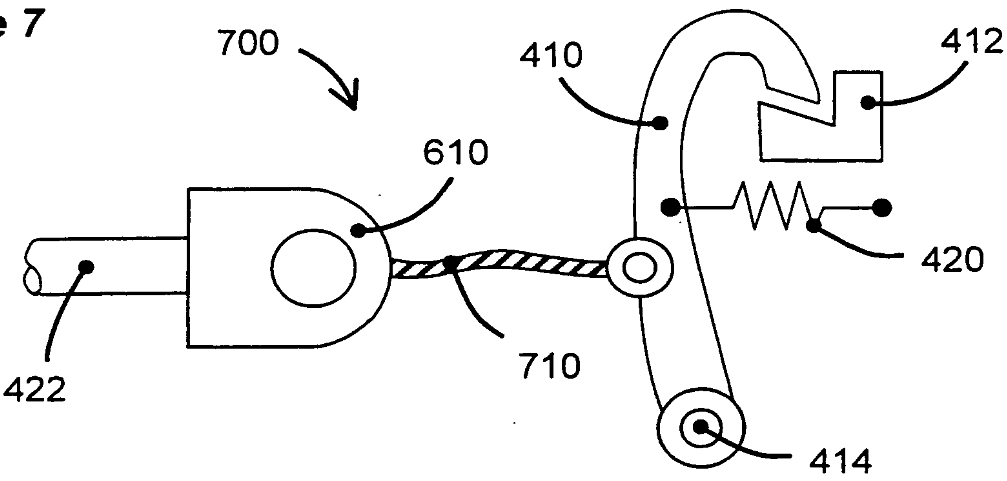


Figure 7



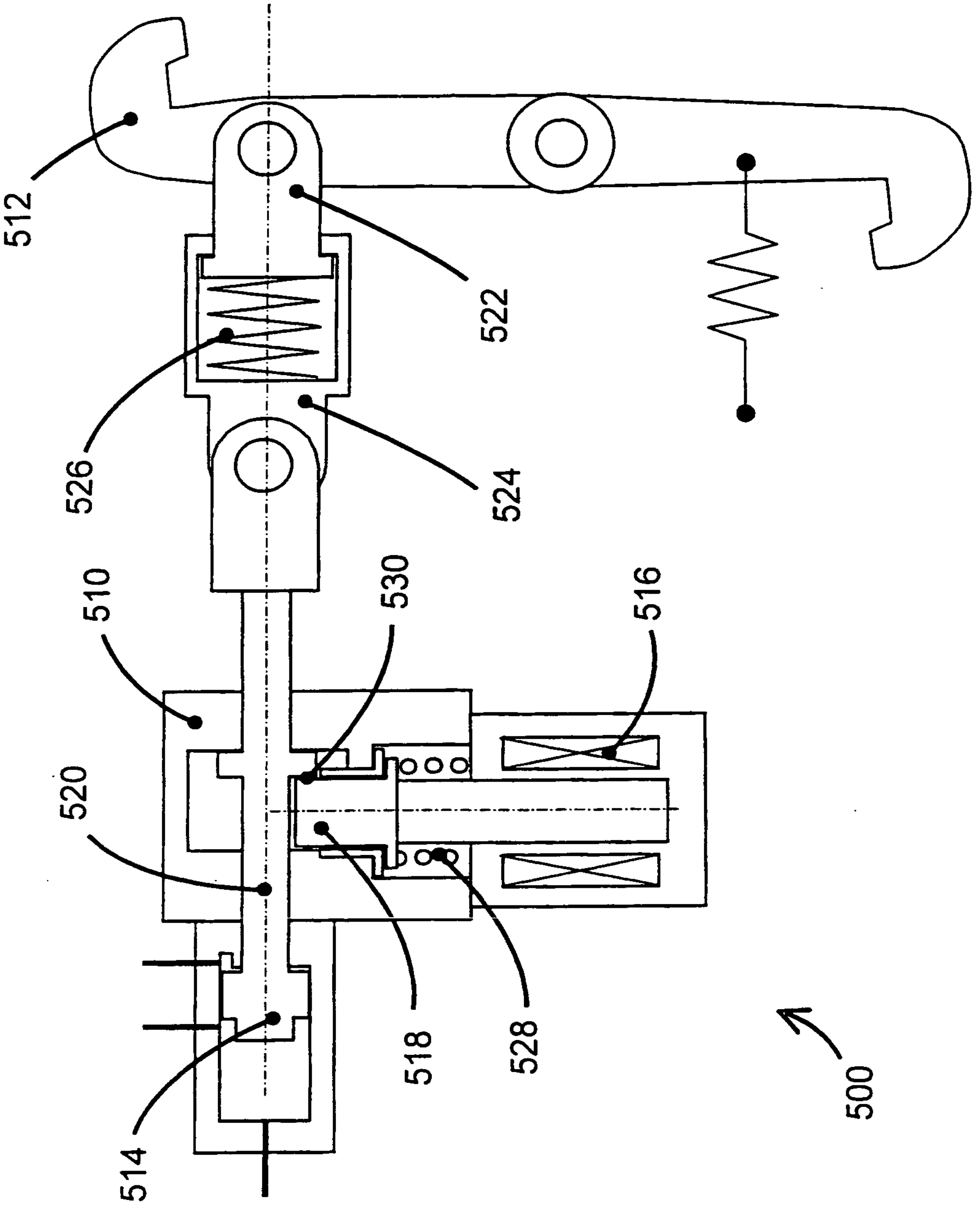


Figure 5

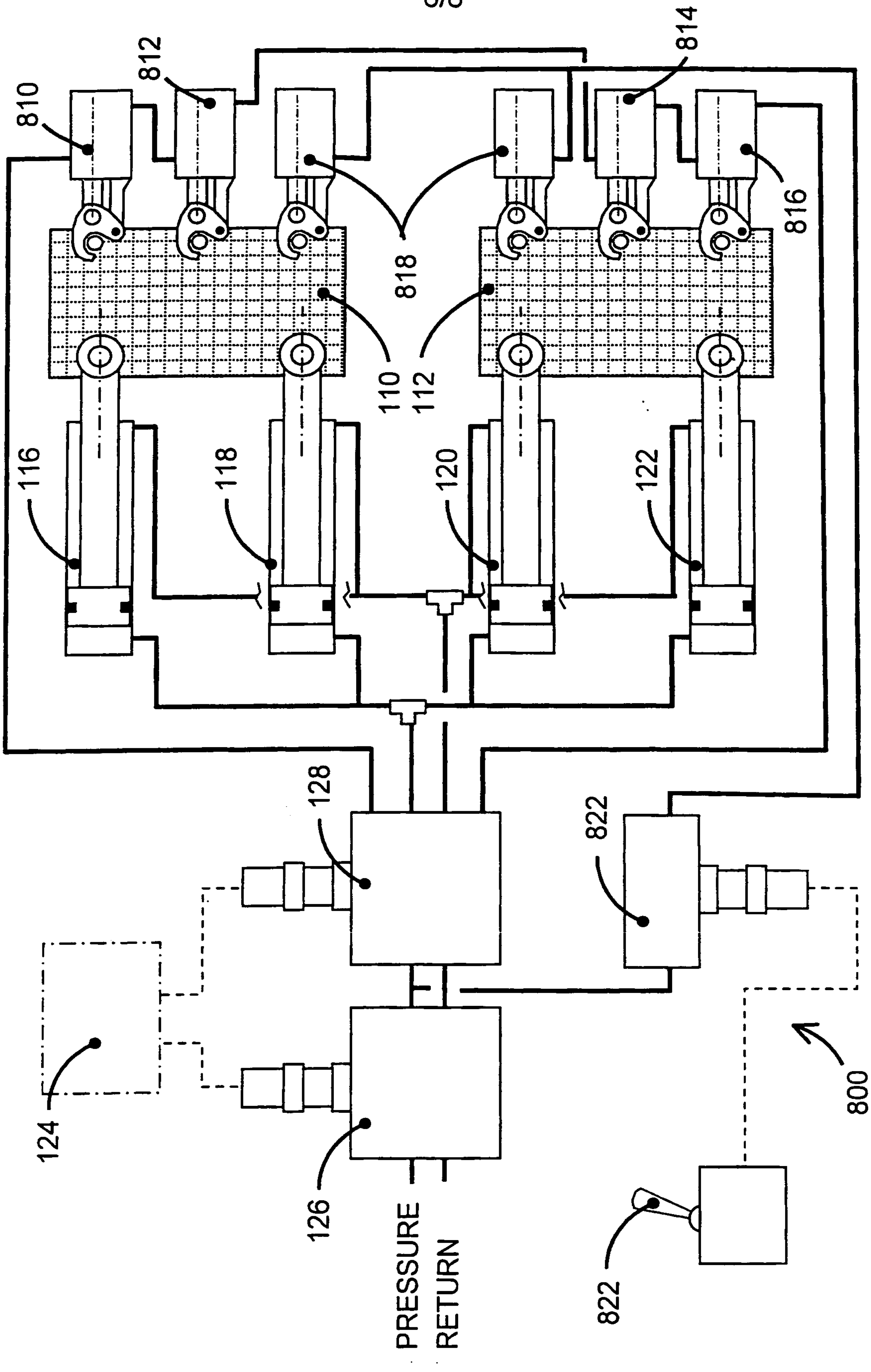

PRESSURE
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Figure 8

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0002392.9 2 February 2000 (02.02.2000) GB

(71) Applicant *(for all designated States except US)*: **SMITHS WOLVERHAMPTON LIMITED** [GB/GB]; Wobaston Road, Wolverhampton WV9 5EW (GB).

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Published:
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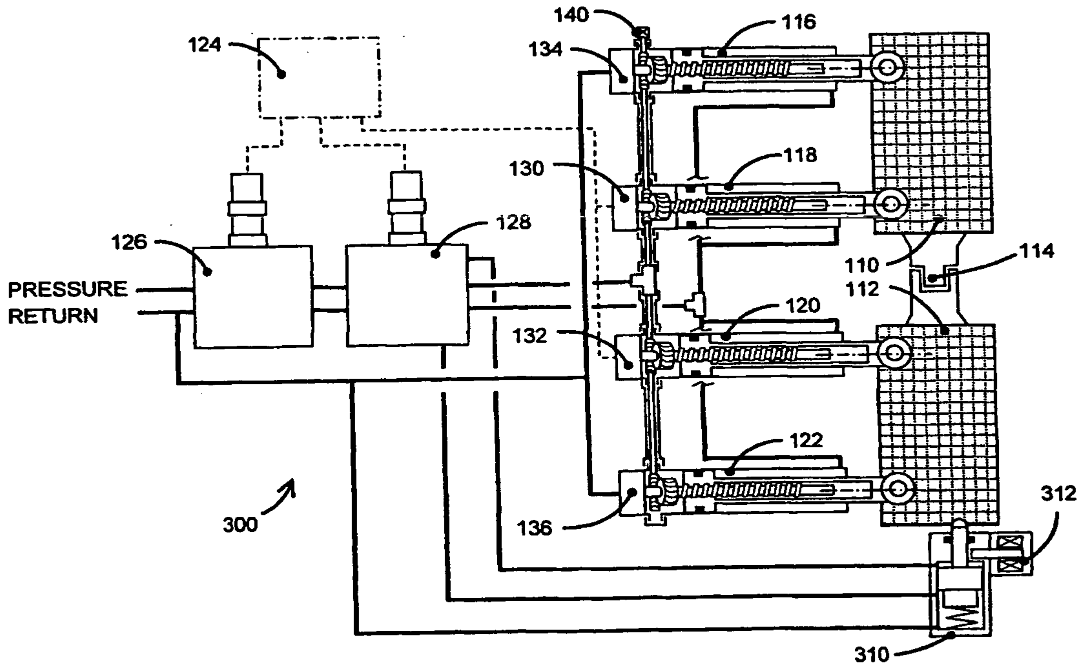
21 March 2002

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: LOCKING DEVICE FOR A THRUST REVERSER



(57) Abstract: A thrust reverser (110, 112) is operated hydraulically but controlled by an independent electrohydraulic lock (310, 312). The electrohydraulic lock (310, 312) comprises a hook (Figure 4: 410) which is connected by a non-rigid link (Figure 4: 416, 418) to a piston (Figure 4: 422) which can be locked by a solenoid operated latch (Figure 5: 518).

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INTERNATIONAL SEARCH REPORT

Inter. .onal Application No
PCT/GB 01/00438

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F02K1/76

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F02K E05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 542 611 A (HUREL DUBOIS AVIONS) 19 May 1993 (1993-05-19) figures ---	1,2,9-12
X	EP 0 801 221 A (LUCAS IND PLC) 15 October 1997 (1997-10-15) abstract ---	1,12
X	US 5 997 054 A (VAUCHEL GUY BERNARD ET AL) 7 December 1999 (1999-12-07) figure 5 ---	3-6,8
X	US 2 780 057 A (HARRY STAVERT) 5 February 1957 (1957-02-05) figure 2 --- -/--	3,5,7,8

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search 1 October 2001	Date of mailing of the international search report 11. 10. 2001
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Raspo, F

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INTERNATIONAL SEARCH REPORT

Inter. onal Application No
PCT/GB 01/00438

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 257 840 A (ROUZAUD DOMINIQUE) 2 November 1993 (1993-11-02) column 2, line 59 -column 3, line 1; figure 1 ---	3-6,8
X	EP 0 890 727 A (HISPANO SUIZA SA) 13 January 1999 (1999-01-13) figures 17,18 ---	3-6,8
X	US 3 576 337 A (GUDDE ROBERT L) 27 April 1971 (1971-04-27) column 5, line 19 - line 22; figures 2-4 -----	3,5,6,8

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 01/00438

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

INTERNATIONAL SEARCH REPORT

Information on patent family members

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